Fendering Systems for Navigation Structures

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Background

- Navigation structures are inherently subjected to impacts loads by transiting vessels

- Significant impacts are typically a result of operator error, loss of control, or loss of power

- Costs of navigation structures will significantly increase if we design based on these extreme events

Barge Impact Accidents

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Tow Lashings

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Fendering Systems

- Overall Goals of Fender Systems
  - Change Energy
    - Conversion of potential energy by gravitational force
    - Conversion of potential energy by buoyancy force
    - Conversion to potential energy by plastic deformation and rebound
    - Dissipation as heat energy by friction
    - Dissipation by permanent plastic deformation

Fendering Systems

- Energy Modes for Fenders
  - Compression
  - Compression/bending
  - Shear
  - Compression/shear
  - Torsion
  - Bending

Fendering Systems

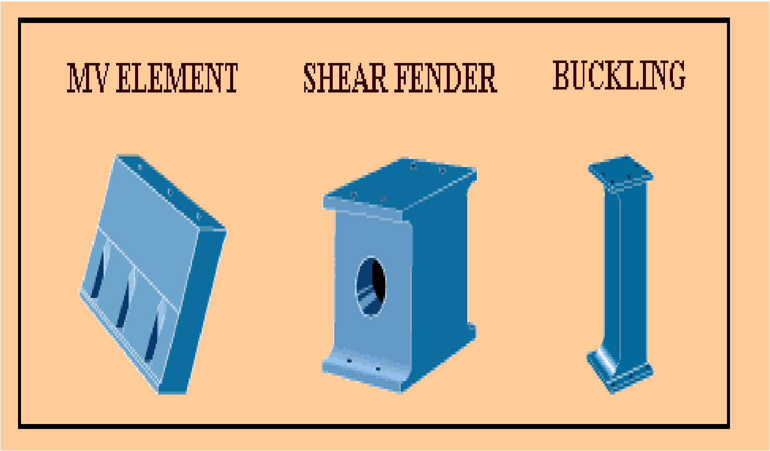
- Overview: Types of Systems
  - Timber - simplest - biggest problem is wear
  - Solid Rubber - compression of rubber material, absorbs high energy - low reaction force
  - Pneumatic - compression of air/oil, moderate energy - low reaction force
  - Foam-filled - compression of resilient foam, high energy absorption - low reaction force
  - Mechanical - springs or hydraulic shock absorbers, stiff and high reaction forces
  - Hybrid - mix of systems above

Different Types of Fender Systems

- Foam-Filled/Pneumatic

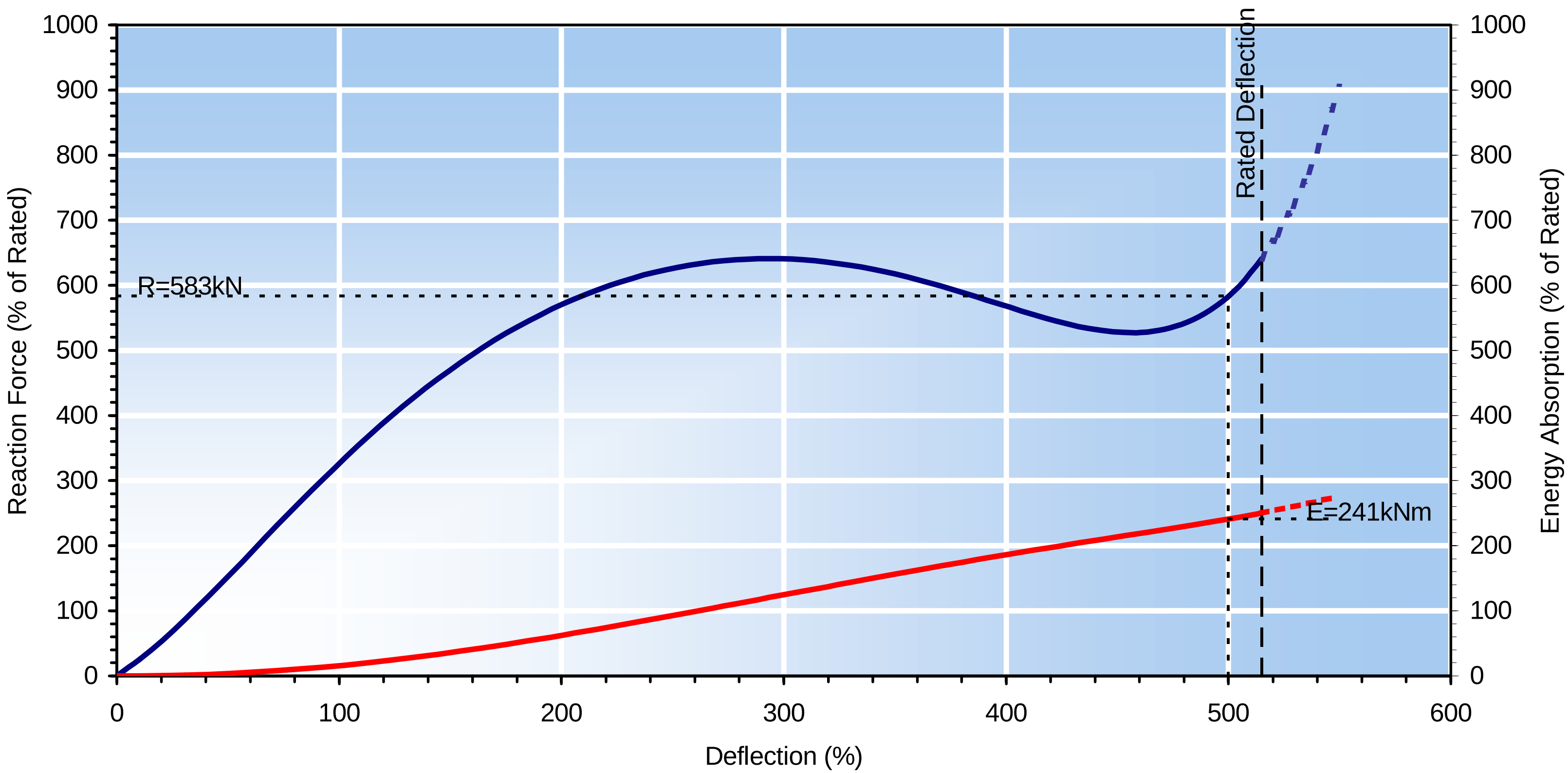
Different Types of Fender Systems

- Solid Rubber/Extruded



Fender Reaction/Energy Curves

1 Pce : AN1000x1000(E2)

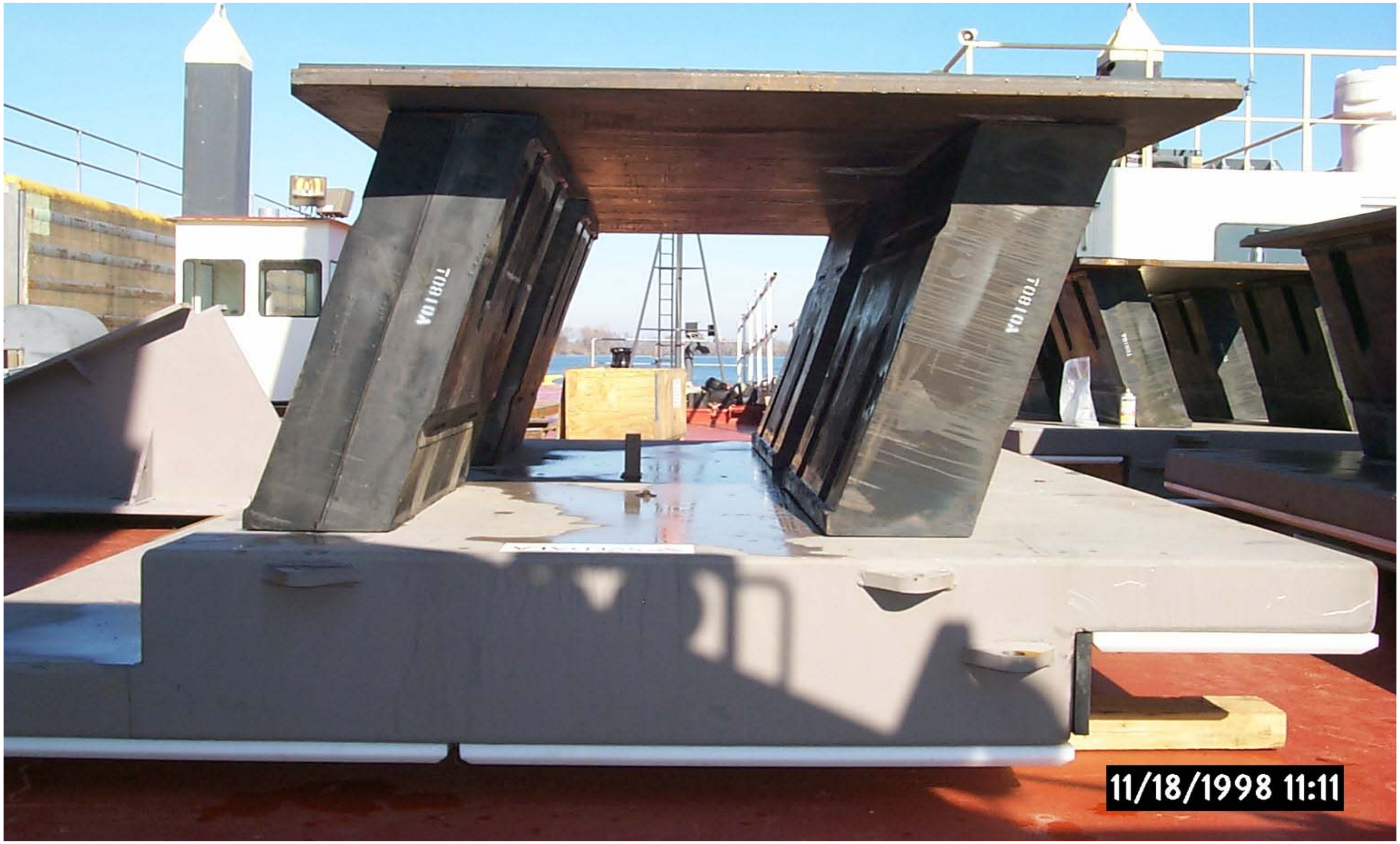


Full-Scale Barge Impact Experiments

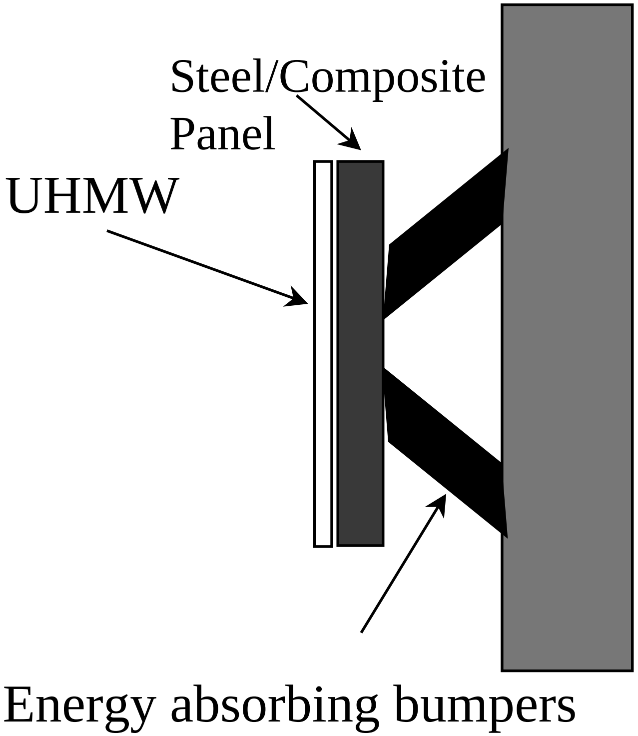
Full-Scale Barge Impact Experiments

- Background on Experiments
  - 32,000 short tons
  - 15 barge tow
  - Velocities from 0.8 to 2.8 ft/s
  - Angles from 7 to 24 degrees
    - 14 experiments on “prototype” fendering system

Prototype Fendering System



Prototype Fendering System

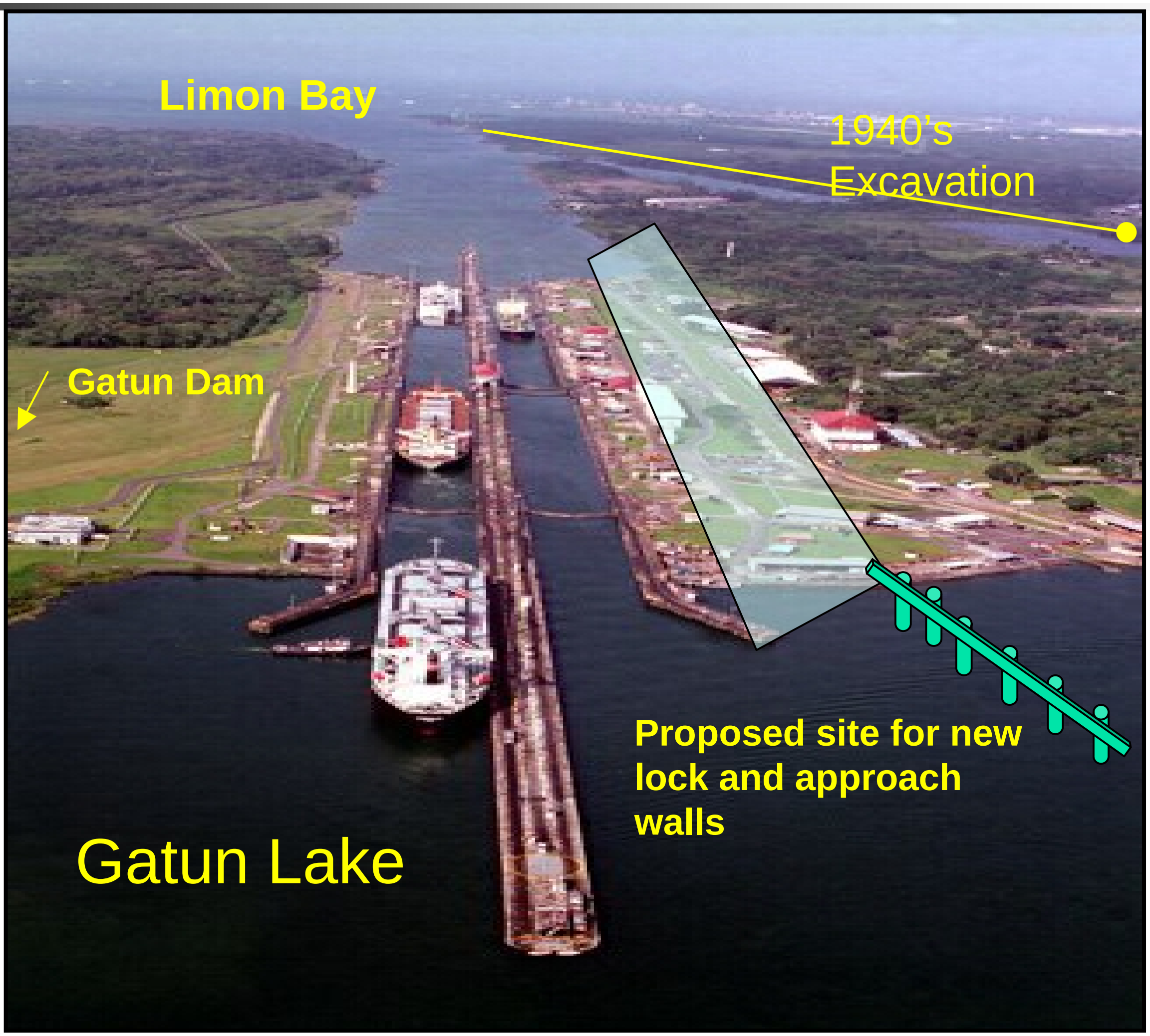


Prototype Fendering System

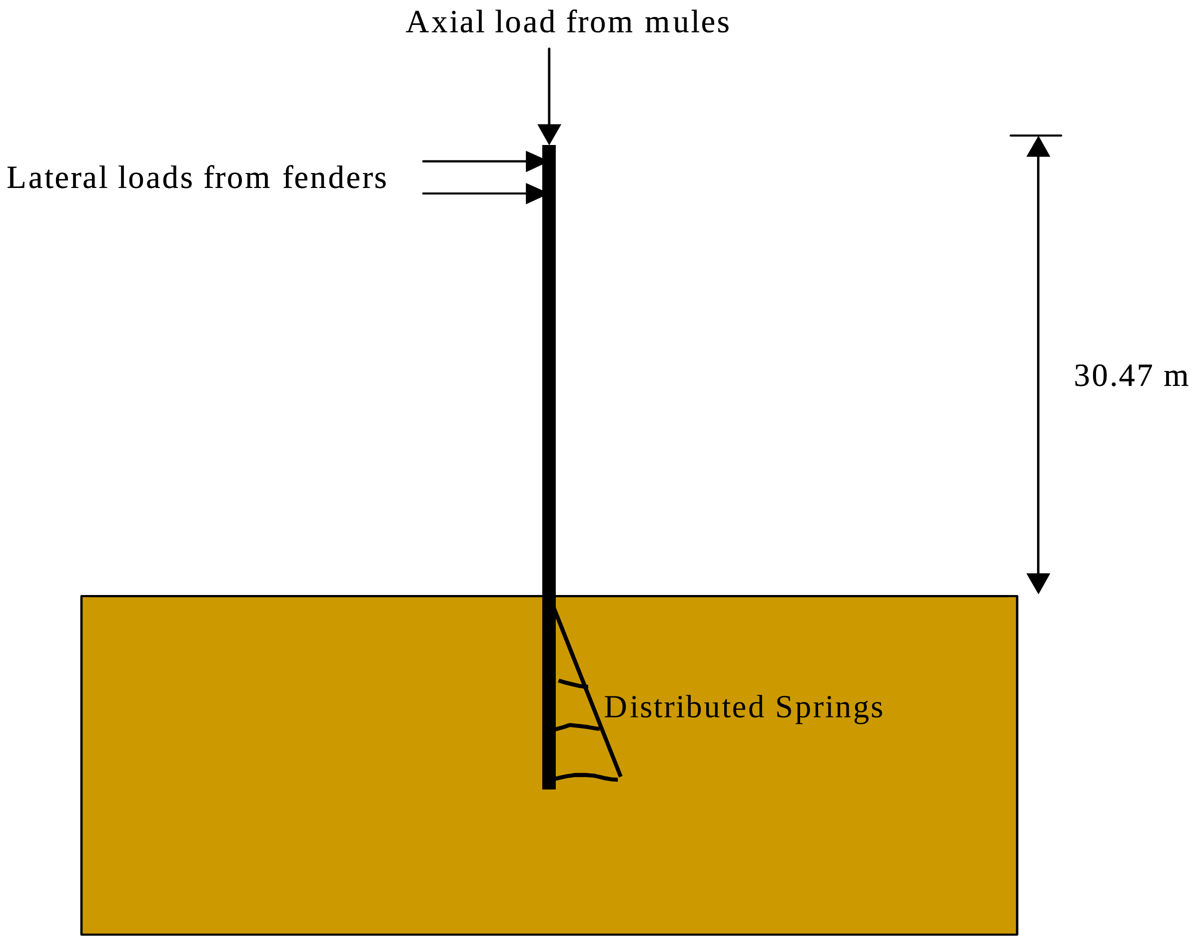
Prototype Fendering System

- Shows high potential for reduction of impact forces
  - Significant force reduction
  - Capability to be fabricated into new structures
  - Low cost alternative
  - Potential applications:
    - Bullnoses
    - Protection cells
    - Upper guide/guard walls
  - Maintenance costs (?)

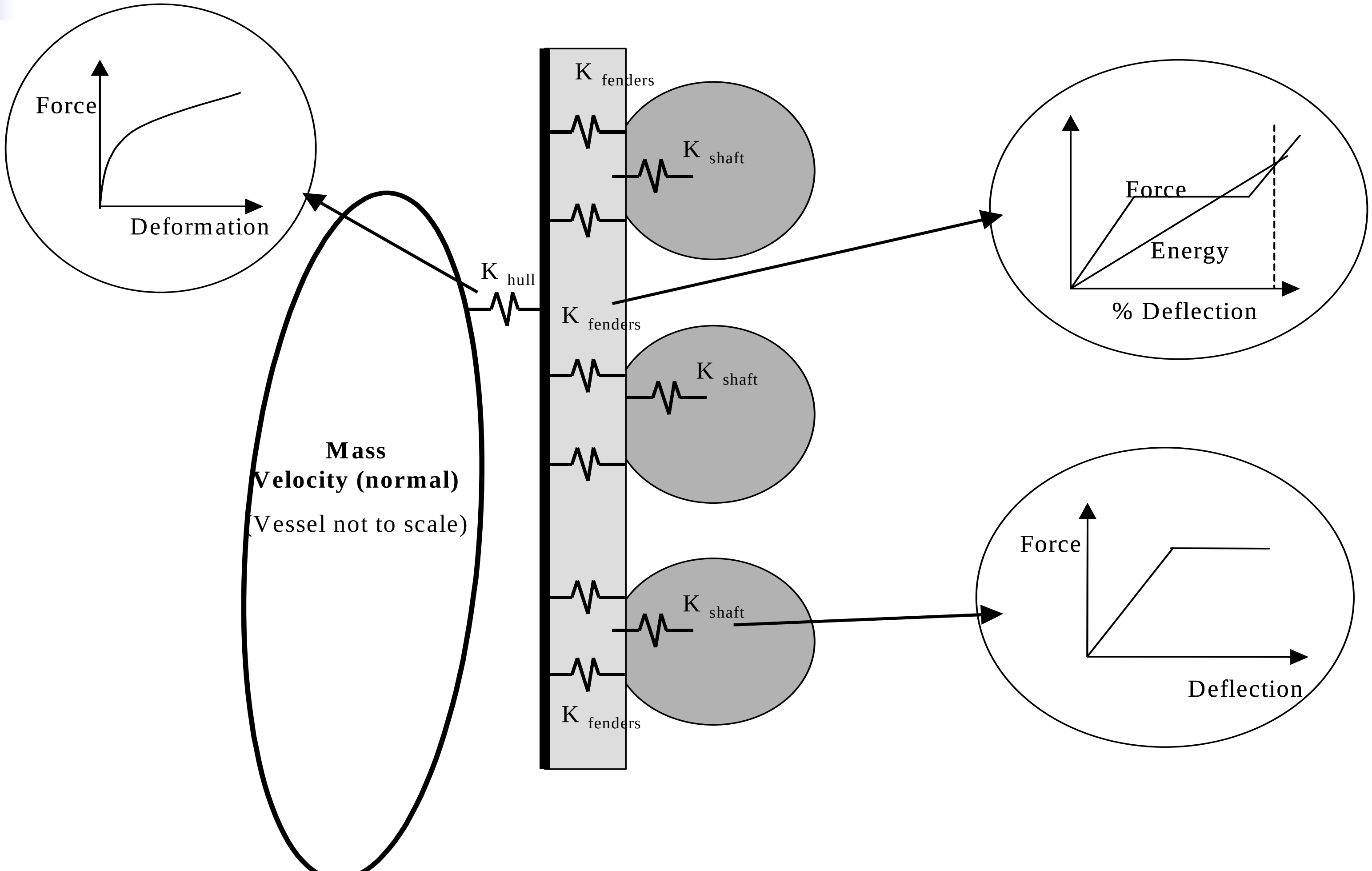
Panama Canal Third Lane – Approach Walls



Panama Canal Third Lane – Approach Walls



Panama Canal Third Lane – Approach Walls



Panama Canal Third Lane – Approach Walls

Panama Canal Third Lane Impact Forces
(revised March 2003)

Vessel Type (displacement)	Load Case	Velocity (normal) (m/sec)	Impact Angle (deg)	Deflection of Fenders (m)	Deflection of Wall (m)	Deformation of Hull (m)	Force (normal to wall) (kN)
METSO MV1400x1000 Fenders on Two 8-ft Drilled Shafts							
ACP Container (Deadweight 110,000 metric tons)							
	Usual	0.064	7	0.11	0.11	0	1079.7
	Unusual	0.18	10	0.9	0.22	0	5050.73
	Extreme	0.4	15	0.9	1.54	0.04	18078.08
ACP Bulker (Deadweight 130,000 metric tons)							
	Usual	0.064	7	0.07	0.07	0	719.8
	Unusual	0.18	10	0.83	0.29	0	2879.32
	Extreme	0.4	15	0.9	1.43	0.04	17041.8

Marmet Lock

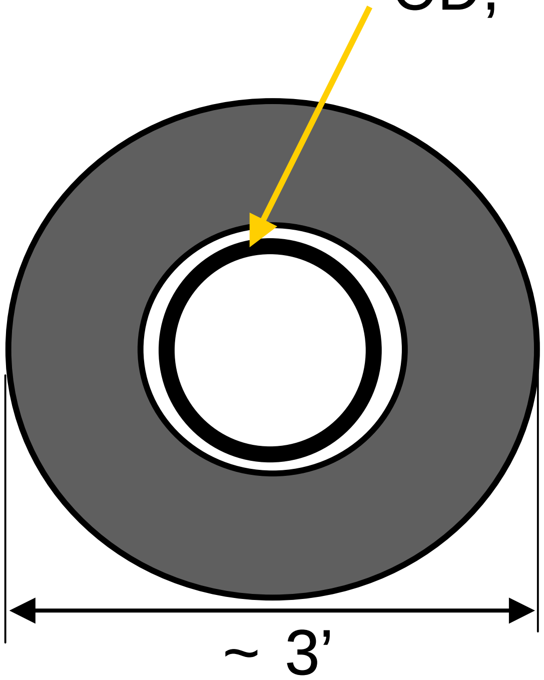
Marmet Lock

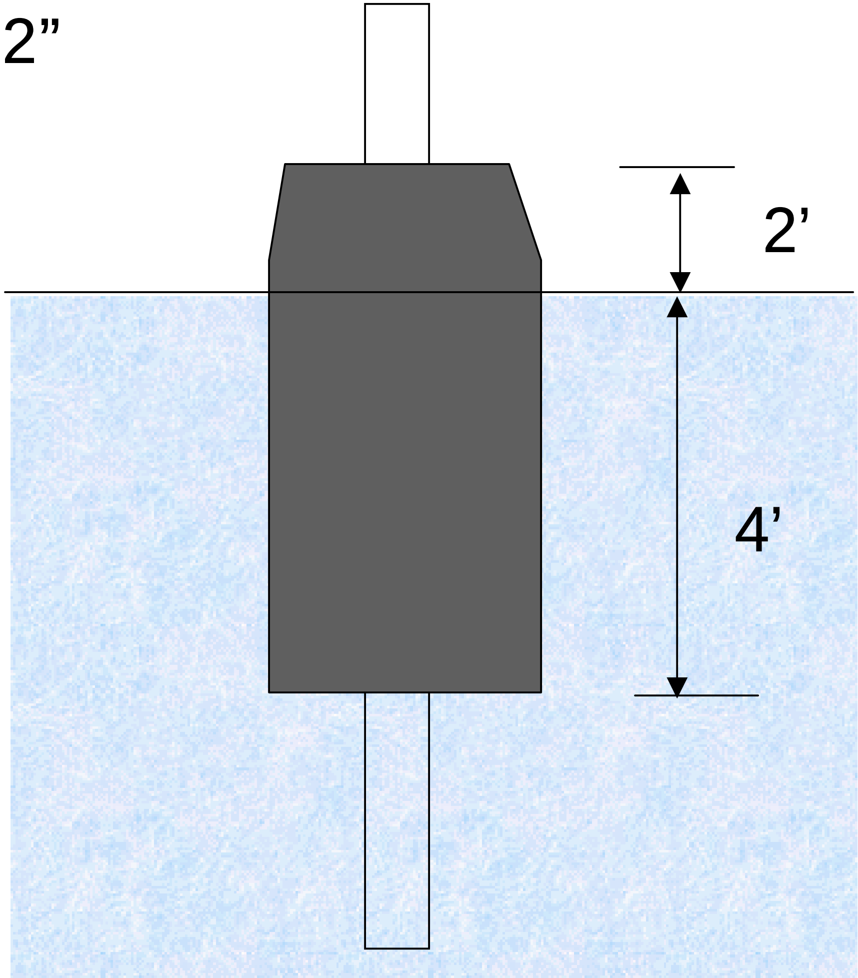
- Project Issues
  - Cofferdam nearing closure and exposed to barge traffic
  - Contract fendering system not in place -Contractor rescheduled fenders to June 04
  - Currently protected by Corps helper boat
- Navigations Restrictions
  - Downbound traffic in land chamber
  - Tow Length Restrictions
  - Delay costs to navigation customer
- Alternatives
  - Navigation Restrictions
  - Continue Helper Boat
  - Alternate Fendering System
  - Restrict Closure of cofferdam/Installation of Needles

Donut Fenders

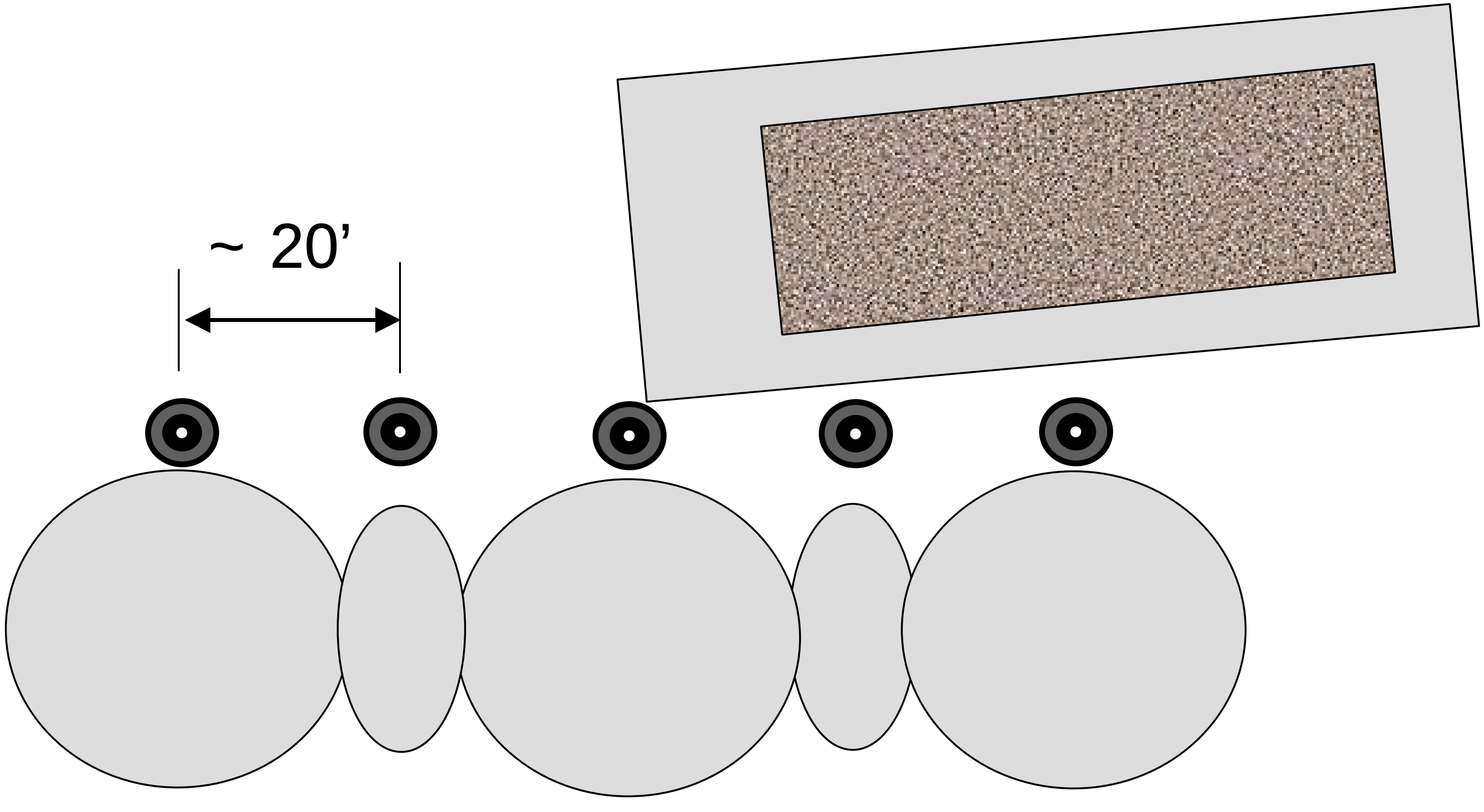
Concept Design of Donut Fenders

Pile Pile – ~12” OD, ~11” ID





Layout of Donut Fenders



Donut Fenders

- Advantages
  - Quick manufacturing and delivery times
    - Lead time - 2-3 weeks
    - Manufactured in Winchester, VA (300 miles away from site)
  - Quick installation times
    - 1-2 weeks depending upon foundation conditions
  - Low to no friction surface
    - Allows tows to slide along
    - Durable and wear resistance
  - Floats with lower pool elevations
    - Bearings allow fenders to move both vertically as well as rotate freely around the pile upon impact

Donut Fenders

- Advantages
  - Proper design can meets design impact forces
    - Requires changes to standard dimensions but is very possible with the right donut and pile
  - Fit limited space requirements
    - Donut designs can meet riverward space of about 3 feet to meet tow alignment (larger on arcs)
    - Donut designs can meet draft requirements of 4 feet below water and 2 feet above
    - Space 3 inches from large cells to permit both sides of donut to absorb energy
  - Removable – easy process
  - Reusable – for other projects

Donut Fenders

- Advantages (cont')
  - Slightly lower cost
    - Need to compare risks and costs for decision
      - Costs of with monthly helper boat, bid cost of fendering system, contractors time frame, removable and reusable system, etc….
- Disadvantages
  - Towing industry may have concerns
    - Not continuous landing surface
      - Fenders for cofferdam are to protect cells not provide guide walls for tows
    - Non-traditional looks
      - Donuts (or upper portions) can be colored to stand out for safety reasons
    - Keep approach/exit speeds down

Conclusions

<u>Issues</u>

- Absorb energy to prevent “breakup” of tow
  - Is technology available - i.e., feasible concept
  - Sacrificial Vs. “No damage” approach
  - Tradeoffs
- Understand behavior during:
  - Fluctuation of pool levels
  - Overtopping from flood events
  - Drift and ice
- Modifications to existing bullnose structures
- Impacts to normal traffic
  - Slow down/speed up approach times

Conclusions

Issues

- Maintenance
  - Wear and tear issues
  - Life cycle costs
- Methods of installation/removal
- Removal/replacement after an impact event
- Benefit-cost analysis
  - Need costs for recent accidents on Ohio River
  - Need costs (construction/maintenance) for various systems

Conclusions

- Fendering Workshop
  - Participants
    - Engineers
    - Operations
    - Industry
  - Learn Design Methods
  - Focus Needs for Navigation

- Field Demonstration Project
  - Cost sharing through CRADA/Industry
  - Monitoring instrumentation